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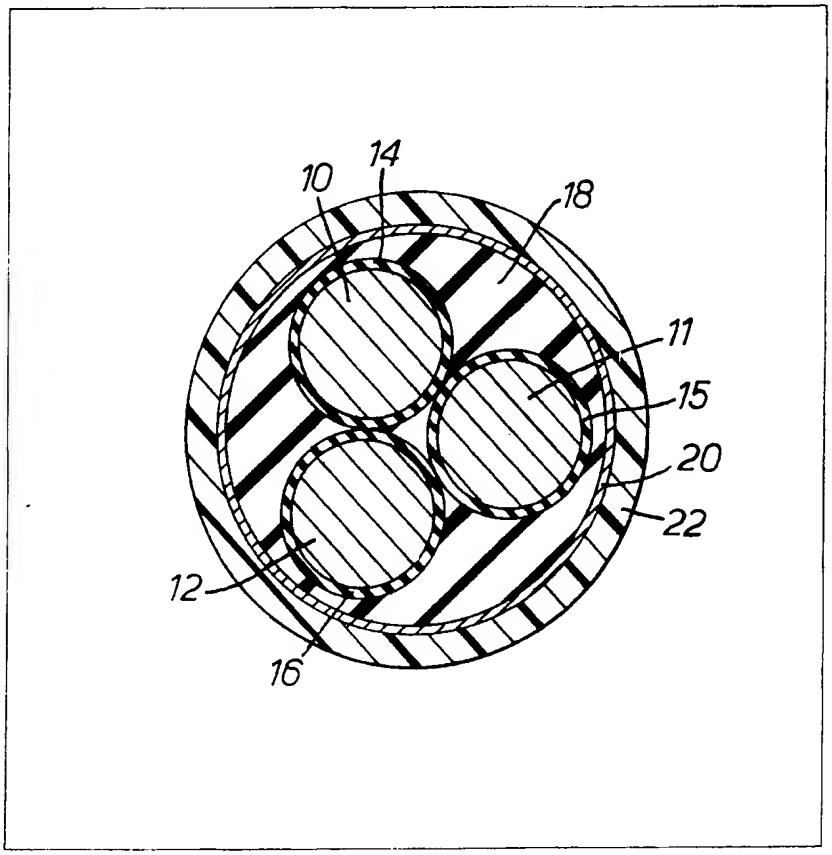
(54) **Flame retardant electric cables**

(57) The flame-retardant cable comprises at least one individually insulated conductor 10, 11, 12 within a sheath 22 of flame-retardant insulating material, and an insulating filling material 18 within the sheath and surrounding the or each individually insulated conductor, the sheath, the insulation on the or each conductor and the filling material being of compositions such that, upon combustion of the cable, no toxic or irritant gases are evolved and no dense smoke is formed.

The improvement comprises that the filling material comprises a major amount of inorganic ash-forming ingredients and a minor amount (such as up to 25% by weight) of at least one cross-linked ethylene copolymer elastomer, the filling material having a tear strength of not greater than 5 Newtons per millimetre. Such a filling material enables the conductors to be manually separated from the material when forming cable terminations.



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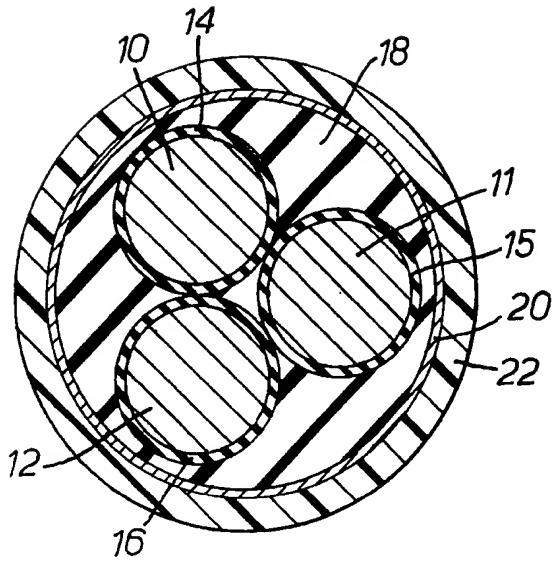
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SPECIFICATION

Flame retardant electric cables

The present invention is concerned with flame-retardant electric cables, particularly such cables having one or more individually insulated conductors for carrying control signals or power.

We have described in our British Specification 1480090 a flame-retardant cable which does not produce dense smoke or toxic or irritant gaseous acids when combusted and which, for this reason, is particularly useful for intallation in tunnels and other enclosed spaces. The cable comprises one or more individually insulated conductors within a sheath of flame-retardant insulating material and an insulating filling material within the sheath and surrounding the individually insulated conductor(s). The sheath, the insulation on each individual conductor and the filling material are of compositions such that, upon combustion of the cable, no toxic or irritant acidic gases are evolved and no dense smoke is formed, and the filling material comprises a flame-retardant. The filling material preferably comprises mainly inorganic ash-forming ingredients, together with a small amount of rubber (such as ethylene-propylene rubber and/or butyl rubber) to render the material extrudable and coherent.

We have now found that, although such cables are satisfactorily flame-retardant, the filling material tends to flow in fire conditions and exude from the cable. Thus, for example, when the filling material is surrounded by a protective layer, such as a layer of wound tape (for example, of silicone rubber-coated glass tape, as disclosed in the above-mentioned British Specification), present between the filing material and the sheath, the filling material tends to become softened and exude through adjacent turns of the tape in fire conditions. It has been found that this exudation contributes to the smoke formation particularly when the ignition source has been removed (that is, when the cable is smouldering).

We have now developed an improved filling material for such a cable.

According to the invention, therefore, there is provided a flame-retardant electric cable, which comprises at least one individually insulated conductor within a sheath of flame-retardant insulating material, and an insulating filling material within the sheath and surrounding the or each individually insulated conductor, the sheath, the insulation on the or each conductor and the filling material being of compositions such that, upon combustion of the cable, no toxic or irritant acidic gases are evolved and no dense smoke is formed, and the filling material comprising a major amount of inorganic ash-forming ingredients and a minor amount (such as up to 25% by weight) of at least one cross-linked ethylene co-polymer elastomer, the filling material having a tear strength not greater than 5 Newtons per millimetre (N/mm) preferably not greater than 3N/mm (measured according to British Standards Specification 6899, Appendix J).

The use of filling material having a tear strength as specified above enables the conductor(s) to be manually separated from the filling material and the sheath when forming cable terminations during installation of the cable; if the tear strength exceeds the value specified above, the formation of terminations becomes undesirably difficult and laborious.

Suitable ethylene copolymer elastomers are, for example, ethylene-vinyl acetate copolymers (EVA), ethylene-acrylate copolymers, ethylene-propylene rubbers (EPR), or ethylene-propylene-diene monomer rubbers (EPDM), or a mixture of two or more thereof.

The elastomer may be cross-linked by means of radiation or by means of a chemical cross-linking agent, such as a peroxide. The use of a chemical cross-linking agent is particularly advantageous as this enables greater thickness of filling material to be cross-linked than can be economically cross-linked by means of radiation. A particularly preferred elastomer is a mixtureof EPDM or EPR and an ethylene-vinyl acetate copolymer.

The elastomer may contain conventional additives such as, for example, lubricants, processing aids, softeners and antioxidants.

The inorganic ash-forming ingredients preferably comprise a filler, such as whiting, and a flame-retardant, such as hydrated alumina.

By way of example, the filling material may have a composition within the ranges specified below:

	parts by weight
EPDM or EPR	33-66
EVA	66-33
Whiting	50-150
Hydrated alumina	150-250
Softeners, lubricants, processing aids	4-10
Peroxide cross-linking agent (40% active)	3-9

An illustrative example of such a composition is as follows:

	parts by weight
Levapren 400 (an EVA copolymer)	70.83
Dutral COO54 (an EPDM rubber)	29.17
Whiting	100.00
Hydrated alumina	218.75
Aflux 42 (a wax blend which acts as lubricant and processing aid)	5.20
Ethylene glycol (processing aid)	2.23
Flectol H (a hydroxyquinoline antioxidant)	0.52
Dicumyl peroxide (40%)	5.83
Zinc oxide	2.60

In this composition, the latter two ingredients are the cross-linking system.

The insulation for the or each conductor may be, for example, a rubber such as non-sulphur cured ethylene-propylene rubber, polyethylene which has been cross-linked chemically or by radiation, non-sulphur cured butyl rubber and thermoplastic rubbers. Thermoplastic polyethylene may be used where, for example, the outer sheath comprises flame-retardant thermoplastic polyethylene, thereby avoiding the need to cure the sheath material, in which case the filling material would need to be cross-linked by radiation.

Thermoplastic rubbers are known in the art. Such rubbers, which are commercially available, are synthetic and extrude easily. At extrusion temperatures, typically 200°C, they are thermoplastic but at ambient temperature their characteristics are those of a conventional rubber. Between the range -40°C to 100°C, they generally have elastic properties, but above 100°C they start to soften and become thermoplastic.

If it is desired to use, for the insulation on the or each conductor, a flame-retardant material, then suitable materials include flame-retardant silicone rubber, flame-retardant cross-linked polyethylene and thermoplastic polyethylene containing an inorganic flame-retardant.

Preferred materials for the sheath include flame-retardant silicone rubber, flame-retardant cross-linked polyethylene, flame retardant compositions containing EVA and/or EPDM, or thermoplastic polyethylene containing an inorganic flame-retardant.

It is sometimes advantageous to provide around the sheath, a protective layer of a silicone rubber-coated glass tape. This protects the cable during installation and also, in the event of combustion, assists in retaining the envelope of ash around the cable.

In order that the invention may be more fully understood, reference is made to the accompanying drawing which is a cross-section of one form of cable according to the invention. Referring to the drawing, there is shown a power cable comprising three conductors 10, 11, 12 having respective individual, extruded insulating layers 14, 15, 16, the three insulated conductors being helically laid-up together. Each conductor may be round as shown or any suitable shape in cross-section. An insulating filling material 18, which is as described above, fills the spaces between the adjacent insulated conductors and gives the laid-up conductor construction a circular outer surface. The filling material is applied by extrusion. A tape 20 may be lapped helically around the conductors after application of the filling material as shown. A sheath 22 is extruded over this, and the cable may be completed by the application of armouring layers (not shown) around the sheath 22.

The sheath 22 is required to be flame-retardant and the material from which it is made can be selected from flame-retardant silicone rubber, such as for example the commercially available Midland Silicone MS1603, flame-retardant cross-linked polyethylene such as, for example, the commercially available Union Carbide HFDC 4770, a flame-retardant composition containing EVA and EPDM, and flame-retardant thermoplastic polyethylene (providing in the latter that the flame-retardant constituents are inorganic compounds only). In addition to the flame-retardant properties of these materials they produce only low quantities of smoke which is free of toxic or irritant acids. The sheath lends mechanical support to the cable to withstand the stresses to which the cable is subjected during handling and installation.

Although a power cable has been described, the invention is applicable to a cable for carrying control signals (for example signalling currents in an underground train system) and to telecommunications cables. The cable will then include a multiplicity of individually insulated conductors enclosed with an extruded sheath and with the spaces within the sheath filled with the filling composition.

CLAIMS

1. A flame-retardant electric cable, which comprises at least one individually insulated conductor within a sheath of flame-retardant insulating material, and an insulating filling material within the sheath and surrounding the or each individually insulated conductor, the sheath, the insulation on the or each conductor and the filling material being of compositions such that, upon combustion of the cable, no toxic or irritant acidic gases are evolved and no dense smoke is formed, and the filling material comprising a major amount of inorganic ash-forming ingredients and a minor amount of at least one cross-linked ethylene copolymer elastomer, the filling material having a tear strength (as defined herein) not greater than 5 Newtons per millimetre.

2. An electric cable according to claim 1, in which the ethylene copolymer elastomer is an ethylene-vinyl acetate copolymer, an ethylene-acrylate copolymer, an ethylene-propylene rubber, an ethylene-propylene-diene monomer rubber, or a mixture of two or more thereof.

3. An electric cable according to claim 2, in which the elastomer is a mixture of an ethylene-vinyl acetate copolymer and either an ethylene-propylene-diene monomer rubber or an ethylene-propylene rubber.

4. An electric cable according to claim 3, in which the filling material contains the following materials (in parts by weight):

ethylene-propylene-diene monomer rubber or ethylene-propylene rubber	33-66
ethylene-vinyl acetate copolymer	66-33
whiting	50-150
hydrated alumina	150-250

5. An electric cable according to any of claims 1 to 4, in which the ethylene copolymer elastomer has been cross-linked by means of a chemical cross-linking agent.

6. A flame-retardant electric cable, substantially as herein described with reference to the accompanying drawing.

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